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Forecasting Volatility in Options Trading - Nexus between Historical Volatility and Implied Volatility

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Abstract

Volatility is the most imperative input in the pricing of an option. As similar to underlying asset price, strike price, risk free rate of interest, remaining time to expiration and dividend, volatility also influences much on option pricing and trading. For a sophisticated trader, option trading is nothing but volatility trading and the trader who can forecast volatility the best is the most successful trader. The objective of this paper is to elucidate the efficiency of the market participants in forecasting the implied volatility using historical volatility and to study the relationship between historical volatility and implied volatility. This is done by considering ten stocks and their respective options which are consistently traded during the years 2014 and 2015. The stocks returns are tested for stationarity and then historical volatility is calculated. Using the Black Scholes option pricing model the implied volatilities are calculated. To check the nexus between historical volatility and implied volatility, Regression Analysis (OLS) and Grangers Casuality Test was conducted through Eviews. It was observed from the study that stock returns are stationary series and the historical and implied volatilities are significantly different and historical volatility does not have casual effect on forecasting implied volatility. This proved that implied volatility cannot be forecasted only by historical volatility, there were other factors (μ) that determines the implied volatility forecasting.

Key Words: Black-Scholes Options Pricing Model, Derivatives, Grangers Casuality Test, Historical Volatility, Implied Volatility, Options, Regression analysis.

1.1 Introduction

1.1.1 Derivatives

Owing to internationalization of financial markets, global financial markets are integrated and results in developing innovative financial instruments and services that leads to a complete market. Invariable change caused by volatile markets and technological development has amplified the risks to businesses. For instance, in 1971 adoption of flexible exchange rate system by eliminating fixed one. Later oil price shocks, sky-scraping inflation, and ample swings in interest rates made difficulties for businesses. Largely, the financial managers, corporate communities demands for innovating new financial products in such a way that to mitigate the risks arising as a result of market price changes. These innovated products are often called as derivatives that are useful in risk management. The growth in use of derivatives has been aided by the development of powerful computing and communication technology, which provides new ways to analyze information about markets as well as the power to process high volumes of payments (Mark A. Walker et. al.)

Financial Derivatives are the financial instruments/contracts between parties to buy/sell the underlying asset at a specified price, specified quantity, specified future time and specified settlement mechanism. These versatile instruments are used as risk management tools too in the market. As these instruments performs several economic functions viz., risk management, price discovery, liquidity and volume trading, and wealth generation. Examples of Derivative Instruments are options on equity, equity index, interest rate, foreign currency, interest rate cap, color and floor, interest rate and currency swaps, options on commodities like gold, silver, crude oil, agricultural commodities etc. Illustrative list of derivative instruments are presented below in Table 01.

Table No. 1: Illustrative list of derivative instruments with respective underlying assets

Type of Contract	Underlying Asset/Variable
Interest Rate Swap	Interest rates
Currency Swap	Currency rates
Commodity Swap	Commodity prices
Equity Swap	Equity prices (equity of another enterprise)
Credit Swap	Credit rating, credit index, or credit price
Purchased or Written Treasury Bond Option (call or put)	Interest rates
Purchased or Written Treasury Bond Option (call or put)	Currency rates
Purchased or Written Treasury Bond Option (call or put)	Commodity prices
Purchased or Written Treasury Bond Option (call or put)	Equity prices (equity of another enterprise)
Interest Rate Futures linked to Government Debt (Treasury Futures)	Interest rates
Currency Futures	Currency rates
Commodity Future	Commodity Prices
Interest Rate Forward linked to Government Debt (Treasury Futures)	Interest rates
Currency Forward	Commodity Prices
Equity Forward	Equity prices (equity of another enterprise)
Equity options	Equity prices/Stock prices
Index options	Index prices/points

1.1.2. Volatility

Volatility is defined as the degree to which the price of a stock or other underlying variables tends to fluctuate over a period of time. A stock that has a wide trading range is said to have a high volatility. Similarly, a stock that has a narrow trading range is said to have a low volatility. Volatility in addition can be stated as short-term fluctuation in the asset prices in the market due to various factors that influences on it. It is crucial to throw light on the matter that volatility is a relative term which means high and low volatility are determined by the volatility relative to each specific underlying variable. In options pricing and trading volatility plays an major role because it has the single biggest effect on the amount of extrinsic value of an option. When there is increase in rate of volatility, the extrinsic value of both call and put options increases and visa-a-versa; this results in expensive option prices. The reason for this is as increase in rate of volatility, the potential range of the stock expands, and the uncertainty of where the stock will finish at expiration increases, thereby extrinsic value of an option increases. Similarly, when there is decrease in the rate of volatility, the extrinsic value of both call and put options decreases.

In options pricing, volatility (both historical and implied volatility) is used as key variable to determine the options extrinsic value. Historical volatility (ex-post volatility) is one of the variable to forecast implied volatility. This means not only the historical volatility is used as a tool for forecasting implied volatility, but some other variables (latest information on stock prices, supply and demand, uncertainty and behavioural factors etc.) also influences on it. Hence, the current paper also addresses this issue. Historical volatility is nothing but, volatility calculated based on past price fluctuations in the market. In the current paper, we calculated the historical volatility by using log returns and closing prices of the underlying stocks (ten companies) for a period of 24 months. For this purpose, collected price data were processed through excel and calculated the log returns and tested for stationarity to check whether these data set (log returns) has a unit root or not. Later, calculated the standard deviation for these log returns, which is so for called as historical volatility.

Implied volatility, which is a value derived by the option pricing model (specifically, Black-Scholes Options Pricing) from the option's price. This indicates the market's acuity of the volatility of the underlying stock during the future life of the contract. In other words, implied volatility can be interpreted as the market expectation of future volatility. Volatility modelling and forecasting have attracted much attention in recent years, largely

enthused by its importance in financial markets. Many asset-pricing models use volatility estimates as a simple risk measure, and volatility appears in option pricing formulas derived from such models as the famous Black-Scholes model and its various extentions (John Knight and Stephen Satchell 2007).

1.2 Review of Literature

The purpose of literature review is to find out the various studies that have been done in the relative fields of the present study and also to understand the various methodologies followed by the authors to arrive at the conclusions. Some of the reviews are as follows;

Several authors have developed option-pricing formulae under alternate assumptions about the underlying asset's return distribution. The models of Merton (1976), Cox and Ross (1976) allow for a Poisson process in security returns. Geske (1979), and Rubinstein (1983) derive formulas in which return variance can be a function of the stock price. On the experiential face, Mandelbrot (1963), Fama (1988), and Blattberg and Gonedes (1974) found the stationary (1og) normal distribution to be an insufficient descriptor of stock returns, and have en suite a range of alternate stationary distributions to the data. Several authors have investigated the time-series properties of stock-return volatilities. Black (1976), Schmalensee and Trippi (1978), Beckers (1980), and Christie (1982) have exposed a persistent imperfect inverse correlation between stock returns and changes in volatility, due to financial leverage effects. Black (1976), Poterba and Summers (1984), and Beckers (1983) present substantiation that shocks to volatility continue but tend to decay over time. Existing option-valuation models cannot fully incorporate the above empirical regularities of volatility behaviour.

1.3 Statement of the Problem

Option pricing designate the future expectations of the market participants. Volatility is the most important input in the pricing of an option. For a sophisticated trader, option trading is nothing but volatility trading and the trader who can forecast volatility the best is the most successful trader. So, forecasting the implied volatility using the historical volatility is the basic consideration of the study. In addition to investigate significant correlation and casual relationship between historical volatility and implied volatility in option pricing and trading.

1.4 Objectives of the Study

The fundamental objective of this research paper is to investigate the nexus between historical volatility and implied volatility in option pricing and trading. In addition, to study the ability of forecasting the implied volatility by the market participants in options trading using historical volatility.

1.5 Scope of the Study

The scope of the study extends till the preview of 10 stocks and their respective options traded consistently during the years 2014 and 2015 in National Stock Exchange of India.

1.6 Data Collection

Data collected was of 10 stocks and their respective options for the period 2014 and 2015. Data is collected from the website NSE INDIA from F&O segment and Equity segment and Yahoo Finance. The 10 stocks are chosen such that the respective options are traded continuously in the period 2014 -2015 and based on the top most stocks and their respective options trading on NSE for the period (Mar 2016).

1.7 Methodology

To calculate the volatility of the stocks in the market, the stationarity of the time series is to be tested. To test whether the stock returns series is random walk time series i.e., non-stationary stochastic process. For this Unit Root Test is calculated with a null hypothesis that time series under consideration is non-stationary.

1.7.1 Calculation of Historical Volatility:

The daily closing prices of the ten individual stocks are collected. Volatility is measured by calculating standard deviation based on log returns on those stocks using excel.

1.7.2 Calculation of Implied Volatility:

In the case of options most of the trading takes place in the near-month options i.e., those options which are maturing within one month. Therefore, only those call options, which have term to maturity as one month are considered. Similarly, the trading data is available for call options with different exercise prices. The exercise price for which volume of trading is highest on the first trading day is considered for the study. Risk-free interest rate is obtained from the trading information on 364-day treasury bill yield (which can be considered as the benchmark risk-free interest rate) published by Reserve Bank of India in its monthly bulletins. Using this data on exercise price, stock price, term to maturity and risk-free interest rate and closing prices of call options, implied volatilities are calculated.

Black Scholes Formula :

$C = S[\ N(d_1)\ ] - Ke^{-rt}\ [N(d_2)\ ]$

$$d1 = \frac{\ln\left(\frac{S}{K}\right) + \left[R+\left(\frac{\sigma 2}{2}\right)\right]t}{\sigma\sqrt{t}}$$

Where,

C = call premium

S = current stock price

t = time until option expiration

K = option striking price

r = risk free interest return

N = cumulative standard normal distribution

1.7.3. Models applied:

a. Test for Stationarity:

Stationary Stochastic Process:

A random or stochastic process is a collection of random variables ordered in time .A stochastic process is said to be stationary if its mean and variance are constant over time and the value of the covariance between the two time periods depends only on the distance or gap or lag between the two time periods and the actual time at which the covariance is computed.

Non Stationary Stochastic Process:

A stochastic process is said to be non stationary if its mean and variance change over time. An example for non stationary is random walk model.

b. Unit Root Test:

A test of stationarity (or non-stationarity) that is well known is the Unit Root Test. The starting point of unit root test is;

$Y_t = \theta y_{t-1} + \mu_t$

Where,

μ_t = white noise term

Yt= random variable at discrete time interval t

If θ =1, then the unit root exist. That is: the time series under consideration is non-stationary or follows a random walk.

If θ! = 1, then unit root does not exist. That is: the time series under consideration is stationary. Theoretically θ value can be calculated by regressing Yt with one period lag values.

c. Augmented Dickey Fuller (ADF) Test:

Augmented Dickey Fuller test is used for testing the unit root or stationarity of the data series.

Hypothesis under ADF Test is;

H0= Time series is non stationary

If θ = 0 (unit root)

H1= Time series is stationary

If θ! =0

Decision Rule:

1) If TAU Stat > ADF critical value → not reject the null hypothesis i.e., unit root exists.

2) If TAU Stat < ADF critical value → reject the null hypothesis i.e., unit root does not exist.

d. Ordinary Least Square

A commonly used method to estimate the regression coefficients is the method of ordinary least squares (OLS). This technique minimizes the sum-of-squared residuals for each equation, accounting for any cross-equation restrictions on the parameters of the system. If there are no such restrictions, this method is identical to estimating each equation using single-equation ordinary least squares. In addition this test can be applied to check the correlation between (to what extent dependent variable is significantly explained by the independent variable) variables and to know is there the problem of auto correlation at the first order.

Hypothesis:

H_0 = Implied volatility is not significantly explained by Historical volatility

H_1 = Implied volatility is significantly explained by Historical volatility

e. Breusch - Godfrey Serial Correlation LM Test

Breusch - Godfrey Serial Correlation LM Test will be used to check the auto correlation problem in the data set and to reject or to accept the hypothesis.

Hypothesis:

$H_0 : \rho = 0$ There is no autocorrelation

$H_1 : \rho \neq 0$ There is autocorrelation

f. Grangers Casuality Test

As per regression analysis, the distinction between the dependent variable Y and one or more independent variable X, the regressors, does not necesarily mean that the independent variable(s) cause dependent variable. Casuality between them if any, must be identified by applying Grangers Casuality test. However, in regressions involving time series data the situation may be different because, as one author puts it,

"time does not run backward. That is, if event A happens before event B, then it is possible that A is causing B. However, it is not possible that B is causing A. In other words, events in the past can cause events to happen today, future events cannot" (Damodar Gujarathi, 2011).

Casuality test estimates under two major assumptions;

i. The future cannot cause the past. The past causes the present or future, and
ii. A cause contains unique information about an e.ect not available elsewhere.

Hypotheses under Grangers Casuality test for the purpose of the current study are;

H_0 = Historical Volatility does not Granger Cause Implied Volatility

H_1 = Historical Volatility has Granger Cause on Implied Volatility

H_0 = Implied Volatility does not Granger Cause Historical Volatility

H_1 = Implied Volatility has Granger Cause on Historical Volatility

1.8. Data Analysis and Interpretation

Following are the results of different models applied and test application for collected time series data;

1. Stationarity Test/ Unit Root Test - ADF Test

Hypothesis

H0 = Log returns have unit root or time series is non stationary

H1 = Log returns are not have unit root or time series is stationary

Table No. 2 TAU Values for Selected Company Stocks

Company	TAU Value
Axis Bank	-4.643693
ICICI Bank	-5.049014
Lupin	-4.643693
Maruthi	-10.67404
Reliance Infrastructure	-4.732987
Reliance Industries	-4.877706
State Bank of India	-4.813199
Tata Motors	-4.587753
Tata Steel	-3.790801
Yes Bank	-4.988468

Source: Author Developed

Table No. 3 Critical Values of ADF Test

Significance Level	Critical Values
1% level	-3.769597
5% level	-3.004861
10% level	-2.642242

Source: Author Developed

Interpretation: Augmented Dickey Fuller test was run to know whether the collected time series data (log returns) are stationary or not. Table No. 2 TAU values for ADF Test indicates calculated t-statistic values for the log returns and Table No. 3 indicates critical values of ADF test at significance levels of 1%, 5% and 10%. Here, from the Table No. 2 it was observed that, all the TAU values are greater than the critical values. Hence, we have to reject the null hypothesis and accept the research hypothesis i.e. log returns are not have unit root or time series is stationary. That means, the mean values and variance are constant over a period of time. Once, the data sets are stationary, we can proceed with the regression test (Ordinary Least Square).

2. Descriptive Statistics

Table No. 4 Descriptive Statistics for Historical Volatilities and Implied Volatilities of selected companies

Company	Descriptive Statistics					
	Historical Volatility			Implied Volatility		
	Kurtosis	Std. Deviation	Jarque-Bera	Kurtosis	Std. Deviation	Jarque-Bera
Axis Bank	5.632826	0.045121	9.831706	8.357454	3.664034	54.27480
ICICI Bank	1.046005	0.889465	2.545399	1.600908	1.284005	1.988911
Lupin	2.167662	0.212104	1.895524	3.525449	7.769281	8.155691
Maruthi	2.566320	2.42396	2.352440	1.924604	1.901710	1.970167
Reliance Infrastructure	4.843051	0.086588	1.982317	3.754947	0.969948	2.274419
Reliance Industries	4.843051	0.103156	2.092594	5.496765	0.589267	10.59740
State Bank of India	7.674783	0.790475	23.33555	3.499347	1.439273	1.999037
Tata Motors	6.206880	0.031145	14.99828	6.697349	3.876667	33.65610
Tata Steel	8.303927	0.029937	53.69009	3.178214	1.76959	3.988562
Yes Bank	5.632826	0.045121	9.831706	8.357454	3.664034	54.27480

Source: Author Developed

Interpretation: Descriptive statistics will be helpful to know whether the data set is having the problem of heteroskedasticity at the first order and to check normality of the data set. Out of several descriptive statistics, Kurtosis, Standard Deviation and Jarque-Bera statistics were considered. The above table provides the results for these statistics. When the Kurtosis values are greater than 3 and with a lower standard deviation, it is said be there is o problem of heteroskedasticity and vice versa. Jarque-Bera statistic is another statistic to check the normality of the data set when the calculated value is more than +1.96 and -1.96. It is clear from the above table that, all ten companies stock's kurtosis values are greater than 3 and the standard deviation for al ten companies stocks are lesser. Hence, it is proved that there is no heterskedasticity. Similarly, Jarque-Bera statistics for all the companies stocks are greater than +1.96 and -1.96, hence, the data sets are normal. This test results shows no heteroskedasticity in the data set at first order, further, to prove, we can proceed with heteroskedasticity test (Breusch-Pagan-Godfrey, Harvey, Glejser, ARCH, White). When there is no heteroskedasticity problem there is no scope to apply ARCH model.

3. Ordinary Least Square Method

Table No. 5 Results of Ordinary Least Square Method

Company	Ordinary Least Square		
	R-Squared	Prob(F-Stat)	DW- Stat
Axis Bank	0.006766	0.702393	1.375157
ICICI Bank	0.0635236	0.218	1.324243
Lupin	0.000023	0.982404	1.255013
Maruthi	0.0623939	0.3822	1.323224
Reliance Infrastructure	0.035349	0.378978	0.345027
Reliance Industries	0.017717	0.636279	1.525893
State Bank of India	0.0211263	0.114061	0.182846
Tata Motors	0.016258	0.809777	0.108619
Tata Steel	0.040830	0.575595	0.728381
Yes Bank	0.006766	0.702393	1.375157

Source: Author Developed

Interpretation: Ordinary Least Square or regression test was applied to estimate the regression coefficients. In addition this minimizes the sum-of-squared residuals for each equation, accounting for any cross-equation restrictions on the parameters of the system. Out of several other statistical values generated through ordinary least square test, only R-Squared, Prob(F-Statistic) or p-value and DW (Durbin Watson) statistics were used to interpret the results. R-Squared value indicates the significant correlation between the variables. Here, in the above table for all ten companies, R-squared value shows that there is very less amount of correlation between historical volatility and implied volatility (say, for Axis Bank 0.006766 indicates the correlation between historical and implied volatilities is 0.6766%). Prob(F-stat) or P-value indicates acceptance or rejection of hypothesis with a significance level. Here, at significance level of 5%, it was proved that for all ten companies, P-value is greater than 0.05. Hence, we failed to accept the research hypothesis or accepting the null hypothesis; i.e. Implied volatility is not significantly explained by Historical volatility due to no significant correlation between the variables. In addition, DW-Statistic is used to check the auto-correlation in the data set with a stated range of standard which is as shown in below;

0 ———————— 2 ———————— 4

+ve AC No AC -ve AC

Note: AC = Auto correlation

DW-Stat will be used for checking first order auto correlation. From the regression analysis for all ten companies we got positive auto correlation at first order. Hence, in later stage to verify this we used Breusch - Godfrey Serial Correlation LM Test.

4. Breusch - Godfrey Serial Correlation LM Test

Table No. 6 Results of Breusch - Godfrey Serial Correlation LM Test

Company	BG Serial Correlation LM Test	
	Prb(X^2)	Prob(F-Stat)
Axis Bank	0.2456	0.2882
ICICI Bank	0.3211	0.3990
Lupin	0.1529	0.1823
Maruthi	0.2245	0.3298
Reliance Infrastructure	0.1751	0.2390
Reliance Industries	0.3247	0.4091
State Bank of India	0.2394	0.3215
Tata Motors	0.0997	0.0790
Tata Steel	0.2198	0.3386
Yes Bank	0.2456	0.2882

Source: Author Developed

Interpretation: Breusch-Godfrey Serial Correlation test will be used for identifying the autocorrelation in the data set after checking through Durbin-Watson Statistic. In order to accept or to reject the hypothesis both Prob(Chi-square) value and Prob(F-Stat) value will be considered with a significance level. Here, with 5% significance level, we got both Prob(Chi-square) and Prob(F-Stat) values for all companies which is greater than 0.05. Hence, we failed to accept the research hypothesis or accepting null hypothesis, i.e., there is no autocorrelation problem in the data set.

5. Grangers Casuality Test

Table No. 7 Results of Grangers Casuality Test

Company	Null Hypothesis			
	HV does not Granger Cause IV		IV does not Granger Cause HV	
	F-Statistic	P-value	F-Statistic	P-value
Axis Bank	0.95771	0.4035	0.85301	0.4436
ICICI Bank	1.21014	0.3424	2.13614	0.1200
Lupin	0.58795	0.5664	0.20567	0.8181
Maruthi	0.48601	0.6234	0.62187	0.5487
Reliance Infrastructure	2.96996	0.0783	1.19160	0.3279
Reliance Industries	0.09725	0.9078	1.72178	0.2085
State Bank of India	1.25302	0.3107	0.82285	0.4559
Tata Motors	0.16444	0.8497	0.34482	0.7132
Tata Steel	1.39704	0.3726	0.01635	0.9839
Yes Bank	0.95771	0.4035	0.85301	0.4436

Source: Author developed

Note: HV and IV = Historical Volatility and Implied Volatility

Interpretation: Grangers Casuality test examines the casual relationship between variables. Casuality relationship between variables can be determined based on calculated F-Statistic and P-values. When F-Statistic is more than 3.84 and the corresponding p-value is less than 0.05 then we have to accept the research hypotheis and vice versa. Here in the above table under the null hypothesis that either historical volatility does not granger cause implied volatility or implied volatility does not granger cause historical volatility, the calculated values of F-Statistic for all the companies are less than 3.84; and P-value for all the companies are more than 0.05. Hence, we are fail to accept the research hypothesis or accepting null hypothesis. Since, future events does not have any effect on past, second category of null hypothesis is not considered here. So, the test results proves historical volatility does not granger cause implied volatility. That means historical volatility does not have casual effect on forecasting implied volatility.

1.9 Conclusions

Volatility is one of the key variable that is influencing on options pricing and its trading. To be successful option trader one should know the importance of volatility and its impact on options prices and trading pattern. For options trader, volatility (more specifically implied volatility) is variability in the rate of return over holding period and hence, it is essential to forecast the implied volatility to know about to what extent risk may be faced by him in options trading. Since, the ARCH family models demands for large data samples, the current study was confined only to regression analysis for a period of 24 months with monthly data set. Further, we did not get the problem of heteroskedasticity in the data set, when there is no heteroskedasticity then the application of ARCH models doesn't have scope to apply. It was observed from the regression analysis that, there is no significant correlation between historical volatility and implied volatility. In addition, market future volatility cannot be used as an estimate for the implied volatility, due to implied volatility is affected by transaction costs, effect of bid-ask spread etc., which are excluded in calculation options price under Black-Scholes option pricing model. From Grangers casuality test it was observed that, historical volatility does not granger cause implied volatility. In other words, historical volatility does not have any casual effect on forecasting implied volatility in options trading. The ability of forecasting the implied volatility by market participants cannot be estimated using only historical volatility of stock returns because the regression analysis conducted proves that the two sample means differ significantly. So, no relation can be proved existing between the historical volatility and implied volatility. Therefore, it is proved from the study that other variables like latest information on stock prices, supply and demand, uncertainty and behavioural factors etc. are also influence on forecasting implied volatility but not only by historical volatility.

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